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(54) **VACUUM PUMPING SYSTEM AND METHOD OF OPERATION**

VAKUUMPUMPENSYSTEM UND BETRIEBSVERFAHREN

SYSTÈME DE POMPAGE DE VIDE ET PROCÉDÉ DE FONCTIONNEMENT

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## Description

[0001] The present invention relates to a vacuum pumping system and to its method of operation.

[0002] Vacuum processing is commonly used in the manufacture of semiconductor devices and flat panel displays to deposit thin films on to substrates, and in metallurgical processes. Pumping systems used to evacuate relatively large process chambers, such as load lock chambers, to the desired pressure generally comprise at least one booster pump connected in series with at least one backing pump.

[0003] A known vacuum pumping system is disclosed in US-A-5 944 049 and comprises a pumping mechanism, a motor for driving the pumping mechanism and a controller for controlling the motor. Another known pumping system is disclosed in EP-1-482-178 which discloses an oil filled rotary vane pump with a controller for controlling the motor.

[0004] Booster pumps typically have oil-free pumping mechanisms, as any lubricants present in the pumping mechanism could cause contamination of the clean environment in which the vacuum processing is performed. Such "dry" vacuum pumps are commonly single or multistage positive displacement pumps employing intermeshing rotors in the pumping mechanism. The rotors may have the same type of profile in each stage or the profile may change from stage to stage. The backing pumps may have either a similar pumping mechanism to the booster pumps, or a different pumping mechanism.

[0005] An asynchronous AC motor typically drives the pumping mechanism of a booster pump. Such motors must have a rating such that the pump is able to supply adequate compression of the pumped gas between the pump inlet and outlet, and such that the pumping speed resulting is sufficient for the duty required.

[0006] A proportion of the power supplied to the motor of the booster pump produces heat of compression in the exhaust gas, particularly at intermediate and high inlet pressure levels, such that the pump body and rotors can heat up. If the amount of compression and differential pressure generated is not adequately controlled, there may be a risk of overheating the booster pump, ultimately resulting in lubrication failure, excessive thermal expansion and seizure. The standard motor for the size and pumping speed of the booster pump is thus usually selected such that it should be able to supply adequate compression in normal use at low inlet pressures but a risk of overheating remains if the pump is operated at intermediate and high inlet pressure levels without a means of protection.

[0007] In the conventional pumping system described above, frequent and repeated operation at high to intermediate inlet pressures may be required. For example, a load lock chamber is repeatedly evacuated from atmospheric pressure to a low pressure to enable a substrate located within the chamber to be transferred to a process chamber, and subsequently exposed to atmospheric pressure to enable the processed substrate to be removed and replaced by a fresh substrate. The amount of gas compression produced by the booster pump, and the differential pressure generated between its inlet and outlet, may be limited by various means to control the amount of heat generated and to limit the risk of overheating. If the gas compression produced by the booster pump is limited too severely, the resulting evacuation time of the large vacuum chamber may be undesirably slow. If the gas compression produced by the booster pump is not limited enough, whilst the resulting evacuation time of the vacuum chamber may be rapid the mechanical booster pump may overheat.

[0008] For driving the motor of a booster pump, a variable frequency drive unit may be provided between the motor and a power source for the motor. Such drive units operate by converting the AC power supplied by the power source into a DC power, and then converting the DC power into an AC power of desired amplitude and frequency. The power supplied to the motor is controlled by controlling the current supplied to the motor, which in turn is controlled by adjusting the frequency and/or amplitude of the voltage in the motor. The current supplied to the motor determines the amount of torque produced in the motor, and thus determines the torque available to rotate the pumping mechanism. The frequency of the power determines the speed of rotation of the pumping mechanism. By varying the frequency of the power, the booster pump can maintain a constant system pressure even under conditions where the gas load may vary substantially.

[0009] In order to prevent overloading of the booster pump, the drive unit sets a maximum value for the frequency of the power ($f_{max}$), and a maximum value for the current supplied to the motor ($I_{max}$). This current limit will conventionally be appropriate to the continuous rating of the motor, and will limit the effective torque produced by the pumping mechanism and hence the amount of differential pressure resulting, thereby limiting the amount of exhaust gas heat generated.

[0010] At the start of a rapid evacuation cycle, it is desirable to rotate the pumping mechanism as rapidly as possible to maximise the evacuation rate. Due to the high pressure, and thus relatively high density, of the gas at the start of the cycle, a large torque is required to rotate the pumping mechanism at a frequency around $f_{max}$, and so there is a high current demand, which is generally greater than $I_{max}$. To protect the motor from damage, the frequency of the power supplied to the motor of the booster pump is rapidly reduced to some level below $f_{max}$, resulting in a sharp reduction in the rotational speed of the pump while limiting the differential pressure produced. As the evacuation progresses and the inlet pressure decreases, the drive unit will ramp up the frequency towards $f_{max}$ over a finite period to gradually increase the rotational speed of the booster pump. While this protects the booster pump from overheating at all inlet pressures, this period when the rotational speed is reduced may represent an undesirable extension of the time required to evacuate the chamber from atmospheric pressure to the desired low pressure (the "pump down" time).

**[0011]** It is an aim of at least the preferred embodiment of the present invention to seek to solve these and other problems.

**[0012]** In a first aspect, the present invention provides a vacuum pumping system comprising an oil free booster pumping mechanism; a motor for driving the booster pumping mechanism; and a controller for controlling the motor, characterised in that the controller is configured to set a maximum value for a rotational frequency of the motor and a maximum value for a current in the motor, and, in order to optimise the performance of the pumping system, is further configured to increase the maximum value for the current in the motor (32) greater than the nominal specification for the motor during operation of the pumping system at a relatively high pressure, and to increase the maximum value for the rotational frequency of the motor during operation of the pumping system at a relatively low pressure.

**[0013]** The system preferably comprises an inverter for supplying a variable frequency power to the motor, the controller adjusting the amplitude and frequency of the power during operation of the pumping system.

**[0014]** The controller is preferably configured to receive input from at least one sensor for monitoring one or more states within the system, and to adjust at least one of the maximum values in dependence on the monitored states. For example, at least one sensor may be configured to supply a signal indicative of a gas pressure within the pumping system, the controller adjusting at least one of the maximum values in dependence on the received signal(s). In another example, at least one sensor may be configured to supply a signal indicative of a temperature of the pumping system, the controller adjusting at least one of the maximum values in dependence on the received signal(s). In yet another example, no external sensors are utilised and instead the controller adjusts at least one of the maximum values in dependence on time only, according to established system configuration and parameters.

**[0015]** In the preferred embodiment, both of these maximum values are varied as the gas pressure decreases during evacuation of the enclosure from atmospheric pressure. The controller is configured to increase the maximum value for the current in the motor ($I_{max}$) during operation of the pumping system at a relatively high pressure, and to increase the maximum value for the rotational frequency of the motor ($f_{max}$) during operation of the pumping system at a relatively low pressure.

**[0016]** In a first, relatively high pressure region, that is, where the pressure at the inlet to the pumping mechanism decreases from atmospheric pressure, $I_{max}$ may be increased to such a value that, during use in this high pressure region, $I_{max}$ is greater than the nominal specification for the motor, and sufficient to allow increased differential pressure to be developed such that the booster inlet pressure attains a lower level, with its outlet venting straight to atmosphere, than would otherwise be possible with the nominal $I_{max}$.

**[0017]** If operated for the entire evacuation cycle with this elevated value of $I_{max}$, there is a risk that the motor may overheat. In view of this, once the pressure falls below a first predetermined value, for example, between 100 mbar and 500 mbar, the value of $I_{max}$ is decreased to allow optimum pumping performance while keeping the generated pressure differential within safe limits to prevent overheating of the pumping mechanism.

**[0018]** When the gas pressure reaches a second predetermined value lower than the first predetermined value, for example, between 1 mbar and 100 mbar, more preferably between 10 mbar and 100 mbar, the density of gas pumped from the enclosure will be inadequate to cause risk of overheating of the pumping mechanism, and so $f_{max}$ can be increased to improve pump performance.

**[0019]** As an alternative to varying the maximum values in dependence on the pressure of gas supplied to the pumping mechanism, at least one of the maximum values may by adjusted in dependence on the pressure of gas exhaust from the pumping mechanism. As further alternatives, these values may be adjusted in dependence on the body temperature of the pumping mechanism and/or on the temperature of the gas entering the pumping mechanism at its inlet port and/or on the temperature of the gas exhausting from the mechanism at its outlet port.

**[0020]** The pumping mechanism is preferably a pumping mechanism of a booster pump for pumping gas from the enclosure. The pumping system may also comprise a primary, or backing, pump having an inlet connected to the exhaust of the booster pump. If allowed to freely vent gas exhaust direct to atmosphere using a separate vent line which does not route through the primary pump, and with no restriction to its rotational speed, the booster pump alone at high inlet pressures can provide a higher net pumping speed than would be achievable being connected through the primary pump, from atmospheric pressure down to an inlet pressure determined by the available motor power. This can assist in achieving a more rapid evacuation of the enclosure than would otherwise result. If this vent line is terminated with a pressure relief valve, it will be open to atmosphere and freely venting whenever the pressure of gas exhaust from the booster pump is above atmospheric pressure, allowing the booster pump to operate at maximum nominal speed. Therefore, the system preferably comprises a pressure relief valve in fluid communication with an exhaust from the booster pumping mechanism for selectively releasing gas compressed by the booster pumping mechanism to the atmosphere. The pressure relief valve is preferably configured to automatically close when the pressure of gas exhaust from the booster pump falls below atmospheric pressure, at which point the primary pump becomes effective in reducing the booster pump outlet pressure further and enhancing the net pumping speed.

**[0021]** The closing of the pressure relief valve can provide a convenient indication of the pressure within the pumping system, and so at least one sensor may be configured to detect the position of the pressure relief valve, and the controller configured to decrease the maximum value of the current in the motor when the pressure relief valve moves from an open position to a closed position.

**[0022]** In a second aspect, the present invention provides a method of controlling a vacuum pumping system comprising an oil free booster pumping mechanism and a motor for driving the booster pumping mechanism, the method comprising the steps recited in claim 25.

**[0023]** Features described above in relation to system aspects of the invention are equally applicable to method aspects of the invention, and vice versa.

**[0024]** Preferred features of the present invention will now be described with reference to the accompanying drawing, in which

Figure 1 illustrates schematically an example of a pumping system for evacuating an enclosure;

Figure 2 illustrates schematically a first embodiment of a drive system for driving a motor of the booster pump of the pumping system of Figure 1;

Figure 3 illustrates in more detail the variable frequency drive unit of the drive system of Figure 2;

Figure 4 is a graph illustrating the variation of the net pumping speed, or evacuation rate, of the enclosure with inlet pressure during operation of the pumping system of Figure 1;

Figure 5 illustrates schematically a second embodiment of a drive system for driving a motor of the booster pump of the pumping system of Figure 1; and

Figure 6 illustrates in more detail the variable frequency drive unit of the drive system of Figure 5.

**[0025]** Figure 1 illustrates a vacuum pumping system for evacuating an enclosure 10, such as a load lock chamber or other relatively large chamber. The system comprises a booster pump 12 connected in series with a backing pump 14. The booster pump 12 has an inlet 16 connected by an evacuation passage 18, preferably in the form of a conduit 18, to an outlet 20 of the enclosure 10. An exhaust 22 of the booster pump 12 is connected by a conduit 24 to an inlet 26 of the backing pump 14. The backing pump 14 has an exhaust 28 that exhausts the gas drawn from the enclosure 10 to the atmosphere.

**[0026]** Whilst the illustrated pumping system includes a single booster pump and a single backing pump, any number of booster pumps may be provided depending on the pumping requirements of the enclosure. Where a plurality of booster pumps are provided, these are connected in parallel so that each booster pump can be exposed to the same operating conditions. Where a relatively high number of booster pumps are provided, two or more backing pumps may be provided in parallel. Furthermore, an additional row or rows of booster pumps similarly connected in parallel may be provided as required between the first row of booster pumps and the backing pumps.

**[0027]** With reference also to Figure 2, the booster pump 12 comprises a pumping mechanism 30 driven by a variable speed motor 32. Booster pumps typically include an essentially dry (or oil free) pumping mechanism 30, but generally also include some components, such as bearings and transmission gears, for driving the pumping mechanism 30 that require lubrication in order to be effective. Examples of dry pumps include Roots, Northey (or "claw") and screw pumps. Dry pumps incorporating Roots and/or Northey mechanisms are commonly multistage positive displacement pumps employing intermeshing rotors in each pumping chamber. The rotors are located on contra-rotating shafts, and may have the same type of profile in each chamber or the profile may change from chamber to chamber.

**[0028]** The backing pump 14 may have either a similar pumping mechanism to the booster pump 12, or a different pumping mechanism. For example, the backing pump 14 may be a rotary vane pump, a rotary piston pump, a Northey, or "claw", pump, or a screw pump. A backing pump motor 34 drives the pumping mechanism of the backing pump 14.

**[0029]** The motor 32 of the booster pump 12 may be any suitable motor for driving the pumping mechanism 30 of the booster pump 12. In the preferred embodiment, the motor 32 comprises an asynchronous AC motor. A control system for driving the motor 32 comprises a variable frequency drive unit 36 for receiving an AC power supplied by a power source 38 and converting the received AC power into a power supply for the motor 32.

**[0030]** Figure 3 illustrates the drive unit 36 in more detail. The drive unit 36 comprises an inverter 40 and an inverter controller 42. As is known, the inverter 40 comprises a rectifier circuit for converting the AC power from the power source 38 to a pulsating DC power, an intermediate DC circuit for filtering the pulsating DC power to a DC power, and an inverter circuit for converting the DC power into an AC power for driving the motor 32.

**[0031]** The inverter controller 42 controls the operation of the inverter 40 so that the power has a desired amplitude and frequency. The inverter controller 42 adjusts the amplitude and frequency of the power in dependence on an operational state of the pumping system. In the example shown in Figures 2 and 3, the inverter controller 42 controls the power in dependence on a gas pressure within the pumping system. As illustrated, the inverter controller 42 receives a first signal indicative of the pressure at the inlet 16 of the booster pump 12 from a first pressure sensor 44 for detecting the pressure within the conduit 18. Alternatively, or in addition, the inverter controller 42 may receive a second signal indicative of the pressure at the exhaust 22 of the booster pump 12 from a second pressure sensor 46 for detecting the pressure within the conduit 24. The inverter controller 42 then varies the power in dependence on one, or both, of the first and second signals. When the frequency of the power output from the inverter 40 varies, the speed of rotation of the motor 32 varies in accordance with the change in frequency. The drive unit 36 is thus able to vary the speed of the booster pump 12 during the evacuation of the enclosure 10 to optimise the performance of the booster pump 12.

**[0032]** The inverter controller 42 sets values for two or more operational limits of the drive unit 36; in particular, the maximum frequency of the power supplied to the motor 32 ($f_{max}$), and the maximum current that can be supplied to the motor 32 ($I_{max}$). As mentioned above, the value of $I_{max}$ is normally set so that it is appropriate to the continuous rating of the motor 32, that is, the power at which the motor can be operated indefinitely without reaching an overload condition. Setting a maximum to the power supplied to the motor has the effect of limiting the effective torque available to the pumping mechanism 30. This in turn will limit the resulting differential pressure across the booster pump 12, and thus limit the amount of heat generated within the booster pump 12.

**[0033]** The inverter controller 42 also monitors the current supplied to the motor 32. The current supplied to the motor 32 is dependent upon the values of the frequency and amplitude of the AC power supplied to the motor 32 by the drive unit 36. In the event that the current supplied to the motor 32 exceeds $I_{max}$, the inverter controller 42 controls the inverter 40 to rapidly reduce the frequency and amplitude of the power supplied to the motor 32, thereby reducing both the current below $I_{max}$ and the speed of the booster pump 12.

**[0034]** Returning to Figure 1, a branch conduit 48 is connected to the conduit 24 extending between the exhaust 22 of the booster pump 12 and the inlet 26 of the backing pump 14. The branch conduit 48 terminates in an overpressure relief valve 50. When the pressure in the conduit reaches a predetermined pressure, which, in this example is around, or slightly above, atmospheric pressure, the relief valve 50 opens to release compressed gas within the conduit 24 to the atmosphere. As illustrated in Figures 2 and 3, a sensor 52 may be provided for outputting a signal indicative of the position of the relief valve 50, which signal is also supplied to the inverter controller 42. The inverter controller 42 thus may receive signals from the sensors 44, 46 indicative of the pressure at the inlet 16 and at the outlet 22 of the booster pump 12 respectively, and a signal from the sensor 52 indicative of the position of the pressure relief valve 50.

**[0035]** A method of operating the pumping system illustrated in Figures 1 to 3 to evacuate the enclosure 10 from atmosphere to a desired pressure will now be described.

**[0036]** At high inlet pressures during the initial stage of the evacuation of the enclosure 10, the pressure of the gas exhaust from the booster pump 12 will, due to the compression of the gas by the pumping mechanism 30 of the booster pump 12, be above atmospheric pressure, and so the pressure relief valve 50 opens to allow gas exhaust from the booster pump 12 to be vented directly to the atmosphere in order to improve the net pumping speed of the pumping system.

**[0037]** As mentioned above, the inverter controller 42 pre-sets values for $I_{max}$ and $f_{max}$ that are appropriate to the continuous rating of the motor 32, that is, the power at which the motor can be operated indefinitely without reaching an overload condition. During this initial stage of operation of the pumping system, due to the relatively high pressure of the gas passing through the booster pump 12, a high current is required to provide sufficient torque to the motor 32 to rotate the pumping mechanism 30 at a frequency approaching $f_{max}$ and to produce substantial differential pressure across the mechanism in order to pump down to a satisfactory intermediate pressure. The optimum current for this may be generally greater than the usual value of $I_{max}$. In order to maximise the pumping capability of the booster pump 12 during this initial stage of the evacuation of the enclosure 10, the value for $I_{max}$ is temporarily increased to a value that allows the full capacity of the booster pump 12 to be utilised, that is, to a value higher than the normal rating of the motor. The booster pump is thus temporarily "overloaded" in order to prolong the increased rate of evacuation of the enclosure during this initial, high pressure stage of the evacuation of the enclosure 10, as indicated at "H" in Figure 4, which illustrates at 53 the variation of net pumping speed, or evacuation rate, of the enclosure 10 with inlet pressure during operation of the pumping system in comparison to a similar variation, illustrated at 55, for the pumping system where $f_{max}$ and $I_{max}$ are not varied during operation. Alternatively, a motor substantially larger than that normally fitted to the booster pump and having a higher current rating may be utilised so that the temporarily increased value of $I_{max}$ does not, in fact, represent any motor overload condition.

**[0038]** To prevent overheating of the booster pump 12 due to prolonged operation with the elevated value of $I_{max}$, the value of $I_{max}$ is subsequently returned to the pre-set value:

- after a first predetermined time period has elapsed; or
- when a gas pressure in the pumping system has reached a first predetermined value.

**[0039]** This first predetermined value may be detected from a signal received from any of the sensors 44, 46, 52. For example, as indicated at 54 in Figure 4, this overloading of the booster pump 12 may be terminated when the gas pressure at the inlet 16 of the booster pump 12, as indicated by the signal output from the sensor 44, falls below a first predetermined value, which in the illustrated example is around 200 mbar. As an alternative, the overloading of the booster pump 12 may be terminated when the gas pressure at the exhaust 22 of the booster pump 12, as indicated by the signal output from the sensor 46, falls below a first predetermined value, which in the illustrated example is around atmospheric pressure. This may be conveniently detected by the closure of the pressure relief valve 50, as input to the inverter controller 42 by the sensor 52. Any one of the signals output from these three sensors 44, 46, 52 may therefore be used as a trigger to reduce the value of $I_{max}$. The consequence of $I_{max}$ reduction at this point will typically be a reduction in the booster motor rotational speed.

**[0040]** Reduction of the value of $I_{max}$ to the preset value during the second, intermediate pressure stage of the evacuation of the enclosure 10 (as indicated at "I" in Figure 4), enables optimum booster pump performance during this intermediate pressure stage while maintaining the pressure differential generated by the booster pump 12 within a limit that prevents overheating of the booster pump 12. As the closure of the pressure relief valve 50 has placed the primary pump 14 in fluid communication with the booster pump 12, the primary pump 14 now becomes effective in enhancing the net pumping speed of the pumping system, which, as illustrated in Figure 4, steadily increases as the pressure at the inlet 16 of the booster pump 12 continues to fall.

**[0041]** As the evacuation progresses and the pressure at the inlet 16 of the booster pump 12 decreases, the inverter controller 42 gradually increases the frequency of the power supplied to the motor 32 to maintain the current around $I_{max}$ to maximise the pumping speed. As the pressure of the gas entering the booster pump 12 decreases, the density of this gas also decreases, and so the risk of overheating of the booster pump 12 decreases as the inlet pressure decreases. In view of this, in order to maximise the performance of the booster pump 12 during the further evacuation of the enclosure 10, the inverter controller 42 increases the value of $f_{max}$ for a third, low pressure stage of the evacuation of the enclosure 10 (as indicated at "L" in Figure 4). The increase of the value of $f_{max}$ may be triggered by:

- the expiry of a second, predetermined time period; or
- when a gas pressure in the pumping system has reached a second predetermined value lower than the first predetermined value.

This second predetermined value may be detected from a signal received from any of the sensors 44, 46. For example, as indicated at 56 in Figure 4, the value of $f_{max}$ may be increased when the gas pressure at the inlet 16 of the booster pump 12, as indicated by the signal output from the sensor 44, falls below a second predetermined value, which in the illustrated example is around 30 mbar. As an alternative, $f_{max}$ may be increased when the gas pressure at the exhaust 22 of the booster pump 12, as indicated by the signal output from the sensor 46, falls below a second predetermined value. Clearly, where the first and second predetermined values are determined from the input from sensor 44 only, the sensors 46, 52 need not be provided. Alternatively, the relationship(s) between two, or more, pressure signals may be used to derive a suitable control signal.

**[0042]** The pumping system is thus able to combine the benefits of the booster pump 12 exhausting to atmosphere at high inlet pressures with increased pumping speed, while retaining control over operating temperatures at intermediate inlet pressures, and further providing enhanced pumping speed at low pressures.

**[0043]** An alternative technique for controlling the drive unit 36 is illustrated in Figures 5 and 6. This technique is similar to that described with reference to Figures 2 and 3, with the exception that in the example shown in Figures 5 and 6, the inverter controller 42 controls the power in dependence on one or more temperatures within the pumping system. As illustrated, the inverter controller 42 receives a first signal indicative of the temperature of the pumping mechanism from a first temperature sensor 60. Alternatively, or in addition, the inverter controller 42 may receive a second signal indicative of the temperature of gas exhaust from the booster pump 12 from a second temperature sensor 62 for detecting the temperature of gas within the conduit 24. Alternatively, or in addition, the inverter controller 42 may receive a third signal indicative of the temperature of gas entering the booster pump 12 from a third temperature sensor 70 for detecting the temperature of gas within the conduit 18. Alternatively, the relationship(s) between two, or more, temperature signals may be used to derive a suitable control signal. The inverter controller 42 then varies the power, and the values for $f_{max}$ and $I_{max}$, in dependence on one, or more, of the first, second and third signals. For example, when one of the temperatures reaches a first predetermined value, the value of $I_{max}$ is returned to the pre-set value, and when one of the temperatures reaches a second predetermined value different from the first value, the value of $f_{max}$ is increased.

## Claims

1. A vacuum pumping system comprising an oil free booster pumping mechanism (30); a motor (32) for driving the booster pumping mechanism; and a controller (36) for controlling the motor, **characterised in that** the controller is configured to set a maximum value for a rotational frequency of the motor and a maximum value for a current in the motor, and, in order to optimise the performance of the pumping system, is further configured to increase the maximum value for the current in the motor (32) greater than the nominal specification for the motor during operation of the pumping system at a relatively high pressure, and to increase the maximum value for the rotational frequency of the motor during operation of the pumping system at a relatively low pressure.

2. A system according to Claim 1, comprising an inverter (40) for supplying a variable frequency power to the motor (32), and wherein the controller (36) is configured to adjust the amplitude and frequency of the power supplied to the motor during operation of the pumping system.

3. A system according to any preceding claim, wherein the controller (36) is configured to receive input from at least one sensor (44, 46, 52; 20, 62, 70) for monitoring one or more states within the system, and to adjust at least one of said maximum values in dependence on the monitored states.

4. A system according to Claim 3, wherein at least one sensor (44, 46, 52) is configured to supply a signal indicative of a gas pressure within the pumping system, and wherein the controller (36) is configured to adjust at least one of said maximum values in dependence on the received signal.

5. A system according to Claim 4, wherein the controller (36) is configured to adjust the maximum value for the current in the motor (32) when the gas pressure is below a first predetermined value.

6. A system according to Claim 5, wherein the first predetermined value is above 100 mbar.

7. A system according to Claim 5 or Claim 6, wherein the controller (36) is configured to adjust the maximum value for the rotational frequency of the motor (32) when the gas pressure is below a second predetermined value, the second predetermined value being lower than the first predetermined value.

8. A system according to Claim 7, wherein the second predetermined value is between 1 mbar and 100 mbar.

9. A system according to Claim 8, wherein the second predetermined value is between 10 mbar and 100 mbar.

10. A system according to Claim 4, wherein two sensors (44, 46; 44, 52) are configured to detect respective different pressures within the pumping system, and the controller (36) is configured to adjust at least one of the maximum values in dependence on a relationship between the detected pressures.

11. A system according to any of Claims 4 to 10, wherein at least one sensor (44) is configured to detect a pressure of a gas conveyed to the pumping mechanism (30).

12. A system according to any of Claims 4 to 11, wherein at least one sensor (46) is configured to detect a pressure of a gas exhaust (22) from the pumping mechanism (30).

13. A system according to any preceding claim, comprising a pressure relief valve (50) in fluid communication with an exhaust (22) from the pumping mechanism (30) for selectively releasing gas compressed by the pumping mechanism to the atmosphere.

14. A system according to Claim 13 when dependent from Claim 5, wherein at least one sensor (52) is configured to detect the position of the pressure relief valve (50), and the controller (36) is configured to adjust at least one of said maximum values depending on the detected position.

15. A system according to Claim 14, wherein the controller (36) is configured to decrease the maximum value for the current in the motor (32) when the pressure relief valve (50) moves from an open position to a closed position.

16. A system according to any of Claims 13 to 15, wherein the pressure relief valve (50) is configured to move from the closed position to the open position when the pressure of gas compressed by the pumping mechanism (30) is above atmospheric pressure.

17. A system according to Claim 3, wherein at least one sensor (60, 62, 70) is configured to supply a signal indicative of a temperature within the pumping system, and wherein the controller (36) is configured to adjust at least one of said maximum values in dependence on the received signals.

18. A system according to Claim 17, wherein the controller (36) is configured to adjust the maximum value for the current in the motor (32) when the temperature is above a first predetermined value.

19. A system according to Claim 18, wherein the controller (36) is configured to adjust the maximum value for the rotational frequency of the motor (32) when the temperature is above a second predetermined value, the second predetermined value being different to the first predetermined value.

20. A system according to Claim 17, wherein two sensors (60, 70; 62) are configured to detect respective different temperatures within the pumping system, and the controller (36) is configured to adjust at least one of the maximum values in dependence on a relationship between the detected temperatures.

21. A system according to any of Claims 17 to 20, wherein at least one sensor (62) is configured to supply a signal indicative of the temperature of gas exhaust from the pumping mechanism (30).

**22.** A system according to any of Claims 17 to 21, wherein at least one sensor (70) is configured to supply a signal indicative of the temperature of gas inlet to the pumping mechanism (30).

**23.** A system according to any of Claims 17 to 22, wherein at least one sensor (60) is configured to supply a signal indicative of the temperature of the pumping mechanism (30).

**24.** A system according to any of Claims 1 and 2, wherein the controller (36) is configured to the maximum values according to a predetermined timing relationship.

**25.** A method of controlling a vacuum pumping system comprising an oil free booster pumping mechanism (30) and a motor (32) for driving the booster pumping mechanism, the method **characterised in that** it comprises the steps of setting a maximum value for a rotational frequency of the motor and a maximum value for a current in the motor, and, during operation of the pumping system, adjusting said maximum values to optimise the performance of the pumping system, wherein the maximum value for the current in the motor (32) is increased to greater than the nominal specification for the motor during operation of the pumping system at a relatively high pressure, and the maximum value for the rotational frequency of the motor is increased during operation of the pumping system at a relatively low pressure..

**26.** A method according to Claim 25, wherein the amplitude and frequency of a power supplied to the motor (32) are adjusted during operation of the pumping system.

**27.** A method according to any of Claims 25 to 26, wherein at least one of said maximum values is adjusted in dependence on one or more operational states of the system.

**28.** A method according to Claim 27, wherein at least one of said maximum values is adjusted in dependence on at least one gas pressure within the pumping system.

**29.** A method according to Claim 28, wherein the maximum value for the current in the motor (32) is decreased when the gas pressure falls below a first predetermined value.

**30.** A method according to Claim 29, wherein the first predetermined value is above 100 mbar.

**31.** A method according to Claim 29 or Claim 30, wherein the maximum value for the rotational frequency of the motor (32) is increased when the gas pressure falls below a second predetermined value, the second predetermined value being lower than the first predetermined value.

**32.** A method according to Claim 31, wherein the second predetermined value is between 1 mbar and 100 mbar.

**33.** A method according to Claim 32, wherein the second predetermined value is between 10 mbar and 100 mbar.

**34.** A method according to Claim 27, wherein at least one of said maximum values is adjusted in dependence on a relationship between two gas pressures within the pumping system.

**35.** A method according to any of Claims 28 to 34, wherein at least one gas pressure is the pressure of a gas conveyed to the pumping mechanism (30).

**36.** A method according to any of Claims 28 to 35, wherein at least one gas pressure is a pressure of a gas exhaust (22) from the pumping mechanism (30).

**37.** A method according to any of Claims 25 to 36, wherein the pumping system comprises a pressure relief valve (50) downstream from the pumping mechanism (30), and at least one of the maximum values is adjusted depending on the position of the pressure relief valve.

**38.** A method according to Claim 37, wherein the maximum value of the current in the motor (32) is decreased when the pressure relief valve (50) moves from an open position to a closed position.

**39.** A method according to Claim 27, wherein at least one of said maximum values is adjusted in dependence on at least one temperature of the pumping system.

**40.** A method according to Claim 39, wherein the maximum value for the current in the motor (32) is decreased when at least one temperature is above a first predetermined value.

**41.** A method according to Claim 40, wherein the maximum value for the rotational frequency of the motor (32) is increased when at least one temperature is above a second predetermined value, the second predetermined value being different to the first predetermined value.

**42.** A method according to Claim 39, wherein at least one of said maximum values is adjusted in dependence on a relationship between at least two temperatures of the pumping system.

**43.** A method according to any of Claims 39 to 42, wherein at least one temperature is the temperature of gas exhaust (22) from the pumping mechanism (30).

**44.** A method according to any of Claims 39 to 43, wherein at least one temperature is the temperature of the pumping mechanism (30).

**45.** A method according to any of Claims 25 to 26, wherein the maximum values are adjusted according to a predetermined timing relationship.

**Patentansprüche**

**1.** Vakuumpumpensystem mit einem ölfreien Vorpumpenmechanismus (30), einem Motor (32) zum Antreiben des Vorpumpenmechanismus, und einem Regler (36) zur Steuerung des Motors, **dadurch gekennzeichnet, dass** der Regler dafür konfiguriert ist, einen Maximalwert für eine Drehzahl des Motors und einen Maximalwert für einen Strom im Motor zu setzen, und der, um die Leistung des Pumpensystems zu optimieren, weiter dafür konfiguriert ist, den Maximalwert für den Strom im Motor (32) bei Betrieb des Pumpensystems auf einem relativ niedrigen Druck größer als der Nennwert für den Motor zu erhöhen, und den Maximalwert für die Drehzahl des Motors während des Betriebs des Pumpensystems auf einem relativ niedrigen Druck zu erhöhen.

**2.** System nach Anspruch 1, mit einem Inverter (40) zum Zuführen eines Stroms mit variabler Frequenz zum Motor (32), wobei der Regler (36) dafür konfiguriert ist, die Amplitude und die Frequenz des zum Motor zugeführten Stroms während des Betriebs des Pumpensystems einzustellen.

**3.** System nach irgendeinem vorhergehenden Anspruch, wobei der Regler (36) dafür konfiguriert ist, ein Eingangssignal von mindestens einem Sensor (44, 46, 52; 20, 62, 70) zum Überwachen eines oder mehrerer Zustände innerhalb des Systems zu empfangen, und mindestens einen der genannten Maximalwerte in Abhängigkeit von den überwachten Zuständen einzustellen.

**4.** System nach Anspruch 3, wobei mindestens ein Sensor (44, 46, 52) dafür konfiguriert ist, ein Signal zu liefern, dass Gasdruck innerhalb des Pumpensystems anzeigt, und wobei der Regler (36) dafür konfiguriert ist, mindestens einen der genannten Maximalwerte in Abhängigkeit von dem empfangenen Signal einzustellen.

**5.** System nach Anspruch 4, wobei der Regler (36) dafür konfiguriert ist, den Maximalwert für den Strom im Motor (32) einzustellen, wenn der Gasdruck sich unterhalb eines ersten vorgegebenen Werts befindet.

**6.** System nach Anspruch 5, wobei der erste vorgegebene Wert oberhalb 100 mbar liegt.

**7.** System nach Anspruch 5 oder Anspruch 6, wobei der Regler (36) dafür konfiguriert ist, den Maximalwert für die Drehzahl des Motors (32) einzustellen, wenn der Gasdruck sich unterhalb eines zweiten vorgegebenen Werts befindet, wobei der zweite vorgegebene Wert niedriger als der erste vorgegebene Wert ist.

**8.** System nach Anspruch 7, wobei der zweite vorgegebene Wert zwischen 1 mbar und 100 mbar liegt.

**9.** System nach Anspruch 8, wobei der zweite vorgegebene Wert zwischen 10 mbar und 100 mbar liegt.

**10.** System nach Anspruch 4, wobei zwei Sensoren (44, 46; 44, 52) dafür konfiguriert sind, jeweils verschiedene Drücke innerhalb des Pumpensystems zu erfassen, und der Regler (36) dafür konfiguriert ist, mindestens einen der Maximalwerte in Abhängigkeit von einem Zusammenhang zwischen den erfaßten Drücken einzustellen.

**11.** System nach einem der Ansprüche 4 bis 10, wobei mindestens ein Sensor (44) dafür konfiguriert ist, einen Druck eines zum Pumpenmechanismus (30) beförderten Gases zu erfassen.

**12.** System nach einem der Ansprüche 4 bis 11, wobei der mindestens eine Sensor (46) dafür konfiguriert ist, einen Druck eines Gasausstoßes (22) aus dem Pumpenmechanismus (30) zu erfassen.

**13.** System nach irgendeinem vorhergehendem Anspruch, mit einem Druckentlastungsventil (50) in Strömungsverbindung mit einem Auslaß (22) aus dem Pumpenmechanismus (30) zum wahlweisen Freisetzen von durch den Pumpenmechanismus komprimiertem Gas in die Atmosphäre.

**14.** System nach Anspruch 13, in Abhängigkeit von Anspruch 5, wobei mindestens ein Sensor (52) dafür konfiguriert ist, die Position des Druckentlastungsventils (50) zu erfassen, und der Regler (36) dafür konfiguriert ist, mindestens einen der genannten Maximalwerte in Abhängigkeit von der erfaßten Position einzustellen.

**15.** System nach Anspruch 14, wobei der Regler (36) dafür konfiguriert ist, den Maximalwert für den Strom im Motor (32) zu vermindern, wenn das Druckentlastungsventil (50) sich von einer offenen Position in eine geschlossene Position bewegt.

**16.** System nach einem der Ansprüche 13 bis 15, wobei das Druckentlastungsventil (50) dafür konfiguriert ist, sich von der geschlossenen Position in die offene Position zu bewegen, wenn der Druck von durch den Pumpenmechanismus (30) komprimiertem Gas oberhalb des atmosphärischen Drucks liegt.

**17.** System nach Anspruch 3, wobei mindestens ein Sensor (60, 62, 70) dafür konfiguriert ist, ein Signal zu liefern, das eine Temperatur innerhalb des Pumpensystems anzeigt, und wobei der Regler (36) dafür konfiguriert ist, mindestens einen der genannten Maximalwerte in Abhängigkeit von den empfangenen Signalen einzustellen.

**18.** System nach Anspruch 17, wobei der Regler (36) dafür konfiguriert ist, den Maximalwert für den Strom im Motor (32) einzustellen, wenn die Temperatur oberhalb eines ersten vorgegebenen Werts liegt.

**19.** System nach Anspruch 18, wobei der Regler (36) dafür konfiguriert ist, den Maximalwert für die Drehzahl des Motors (32) einzustellen, wenn die Temperatur sich oberhalb eines zweiten vorgegebenen Werts befindet, wobei der zweite vorgegebene Wert von dem ersten vorgegebenen Wert verschieden ist.

**20.** System nach Anspruch 17, wobei zwei Sensoren (60, 70; 62) dafür konfiguriert sind, jeweils verschiedene Temperaturen innerhalb des Pumpensystems zu erfassen, und der Regler (36) dafür konfiguriert ist, mindestens einen der Maximalwerte in Abhängigkeit von einem Zusammenhang zwischen den erfaßten Temperaturen einzustellen.

**21.** System nach einem der Ansprüche 17 bis 20, wobei mindestens ein Sensor (62) dafür konfiguriert ist, ein Signal zu liefern, das die Temperatur des Gasausstoßes aus dem Pumpenmechanismus (30) anzeigt.

**22.** System nach einem der Ansprüche 17 bis 21, wobei mindestens ein Sensor (70) dafür konfiguriert ist, ein Signal zu liefern, das die Temperatur von Eintrittsgas in den Pumpenmechanismus (30) anzeigt.

**23.** System nach einem der Ansprüche 17 bis 22, wobei mindestens ein Sensor (60) dafür konfiguriert ist, ein Signal zu liefern, das die Temperatur des Pumpenmechanismus (30) anzeigt.

**24.** System nach einem der Ansprüche 1 und 2, wobei der Regler für die Maximalwerte entsprechend einem vorgegebenen zeitlichen Zusammenhang konfiguriert ist.

**25.** Verfahren zur Steuerung eines Vakuumpumpensystems mit einem ölfreien Vorpumpenmechanismus (30) und einem Motor (32) zum Antreiben des Vorpumpenmechanismus, wobei das Verfahren **dadurch gekennzeichnet ist, dass** es die Schritte des Einstellenes eines Maximalwerts für eine Drehzahl des Motors und eines Maximalwerts für einen Strom im Motor und, während des Betriebs des Pumpensystems, des Einstellens der genannten Maximalwerte zur Optimierung der Leistung des Pumpensystems umfaßt, wobei der Maximalwert für den Strom im Motor (32) auf einen größeren als den Nennwert für den Motor während des Betriebs des Pumpensystems auf einem relativ hohen Druck erhöht wird, und der Maximalwert für die Drehzahl des Motors während des Betriebs des Pumpensystems auf einem relativ niedrigen Druck erhöht wird.

**26.** Verfahren nach Anspruch 25, wobei die Amplitude und die Frequenz eines zum Motor (32) zugeführten Stroms während des Betriebs des Pumpensystems eingestellt werden.

**27.** Verfahren nach einem der Ansprüche 25 bis 26, wobei mindestens einer der genannten Maximalwerte in Abhängigkeit von einem oder mehreren Betriebszuständen des Systems eingestellt wird.

**28.** Verfahren nach Anspruch 27, wobei mindestens einer der genannten Maximalwerte in Abhängigkeit von mindestens einem Gasdruck innerhalb des Pumpensystems eingestellt wird.

**29.** Verfahren nach Anspruch 28, wobei der Maximalwert für den Strom im Motor (32) vermindert wird, wenn der Gasdruck unter einem ersten vorgegebenen Wert abfällt.

**30.** Verfahren nach Anspruch 29, wobei der erste vorgegebene Wert oberhalb 100 mbar liegt.

**31.** Verfahren nach Anspruch 29 oder Anspruch 30, wobei der Maximalwert für die Drehzahl des Motors (32) erhöht wird, wenn der Gasdruck unter einem zweiten vorgegebenen Wert abfällt, wobei der zweite vorgegebene Wert niedriger als der erste vorgegebene Wert ist.

**32.** Verfahren nach Anspruch 31, wobei der zweite vorgegebene Wert zwischen 1 mbar und 100 mbar liegt.

**33.** Verfahren nach Anspruch 32, wobei der zweite vorgegebene Wert zwischen 10 mbar und 100 mbar liegt.

**34.** Verfahren nach Anspruch 27, wobei mindestens einer der genannten Maximalwerte in Abhängigkeit von einem Zusammenhang zwischen zwei Gasdrücken innerhalb des Pumpensystems eingestellt wird.

**35.** Verfahren nach einem der Ansprüche 28 bis 34, wobei mindestens ein Gasdruck der Druck eines zu dem Pumpenmechanismus (30) zugeführten Gases ist.

**36.** Verfahren nach einem der Ansprüche 28 bis 35, wobei mindestens ein Gasdruck ein Druck eines Gasausstoßes (22) aus dem Pumpenmechanismus (30) ist.

**37.** Verfahren nach einem der Ansprüche 25 bis 36, wobei das Pumpensystem ein Druckentlastungsventil (50) stromab des Pumpenmechanismus (30) aufweist, und mindestens einer der Maximalwerte in Abhängigkeit von der Position des Druckentlastungsventils eingestellt wird.

**38.** Verfahren nach Anspruch 37, wobei der Maximalwert des Stroms im Motor (32) vermindert wird, wenn das Druckentlastungsventil (50) sich von einer offenen Position in eine geschlossene Position bewegt.

**39.** Verfahren nach Anspruch 27, wobei mindestens einer der genannten Maximalwerte in Abhängigkeit von mindestens einer Temperatur des Pumpensystems eingestellt wird.

**40.** Verfahren nach Anspruch 39, wobei der Maximalwert für den Strom im Motor (32) vermindert wird, wenn mindestens eine Temperatur oberhalb eines ersten vorgegebenen Werts liegt.

**41.** Verfahren nach Anspruch 40, wobei der Maximalwert für die Drehzahl des Motors (32) erhöht wird, wenn mindestens eine Temperatur oberhalb eines zweiten vorgegebenen Werts liegt, wobei der zweite vorgegebene Wert verschieden von dem ersten vorgegebenen Wert ist.

**42.** Verfahren nach Anspruch 39, wobei mindestens einer der genannten Maximalwerte in Abhängigkeit von einem Zusammenhang zwischen mindestens zwei Temperaturen des Pumpensystems eingestellt wird.

**43.** Verfahren nach einem der Ansprüche 39 bis 42, wobei mindestens eine Temperatur die Temperatur des Gasausstoßes (22) aus dem Pumpenmechanismus (30) ist.

**44.** Verfahren nach einem der Ansprüche 39 bis 43, wobei mindestens eine Temperatur die Temperatur des Pumpenmechanismus (30) ist.

**45.** Verfahren nach einem der Ansprüche 25 bis 26, wobei die Maximalwerte entsprechend eines vorgegebenen zeitlichen Zusammenhangs eingestellt werden.

**Revendications**

**1.** Système de pompage à vide comprenant un mécanisme de pompage à surpresseur sans huile (30) ; un moteur (32) destiné à entraîner le mécanisme de pompage à surpresseur ; et un contrôleur (36) destiné à commander le moteur, **caractérisé en ce que** le contrôleur est configuré pour fixer une valeur maximale pour une fréquence de rotation du moteur et une valeur maximale pour un courant dans le moteur, et, afin d'optimiser la performance du système de pompage, est en outre configuré pour augmenter la valeur maximale pour le courant dans le moteur (32) au-dessus de la spécification nominale pour le moteur pendant le fonctionnement du système de pompage à une pression relativement élevée, et pour augmenter la valeur maximale pour la fréquence de rotation du moteur pendant le fonctionnement du système de pompage à une pression relativement basse.

**2.** Système selon la revendication 1, comprenant un onduleur (40) destiné à fournir une alimentation électrique à fréquence variable au moteur (32), et dans lequel le contrôleur (36) est configuré pour ajuster l'amplitude et la fréquence de la puissance fournie au moteur pendant le fonctionnement du système de pompage.

**3.** Système selon l'une quelconque des revendications précédentes, dans lequel le contrôleur (36) est configuré pour recevoir en entrée des informations en provenance d'au moins un capteur (44, 46, 52 ; 20, 62, 70) pour surveiller un ou plusieurs états dans le système, et pour ajuster au moins l'une desdites valeurs maximales en fonction des états surveillés.

**4.** Système selon la revendication 3, dans lequel au moins un capteur (44, 46, 52) est configuré pour fournir un signal indicatif d'une pression de gaz dans le système de pompage, et dans lequel le contrôleur (36) est configuré pour ajuster au moins l'une desdites valeurs maximales en fonction du signal reçu.

**5.** Système selon la revendication 4, dans lequel le contrôleur (36) est configuré pour ajuster la valeur maximale pour le courant dans le moteur (32) lorsque la pression du gaz est en-dessous d'une première valeur prédéterminée.

**6.** Système selon la revendication 5, dans lequel la première valeur prédéterminée est supérieure à 100 mbar.

**7.** Système selon la revendication 5 ou la revendication 6, dans lequel le contrôleur (36) est configuré pour ajuster la valeur maximale pour la fréquence de rotation du moteur (32) lorsque la pression du gaz est en-dessous d'une seconde valeur prédéterminée, la seconde valeur prédéterminée étant inférieure à la première valeur prédéterminée.

**8.** Système selon la revendication 7, dans lequel la seconde valeur prédéterminée est entre 1 mbar et 100 mbar.

**9.** Système selon la revendication 8, dans lequel la seconde valeur prédéterminée est entre 10 mbar et 100 mbar.

**10.** Système selon la revendication 4, dans lequel deux capteurs (44, 46 ; 44, 52) sont configurés pour détecter des pressions différentes respectives dans le système de pompage, et le contrôleur (36) est configuré pour ajuster au moins l'une des valeurs maximales en fonction d'une relation entre les pressions détectées.

**11.** Système selon l'une quelconque des revendications 4 à 10, dans lequel au moins un capteur (44) est configuré pour détecter une pression d'un gaz acheminé au mécanisme de pompage (30).

**12.** Système selon l'une quelconque des revendications 4 à 11, dans lequel au moins un capteur (46) est configuré pour détecter une pression d'un gaz évacué (22) du mécanisme de pompage (30).

**13.** Système selon l'une quelconque des revendications précédentes, comprenant une valve de limitation de pression (50) en communication fluide avec une évacuation (22) du mécanisme de pompage (30) pour libérer sélectivement le gaz comprimé par le mécanisme de pompage à l'atmosphère.

**14.** Système selon la revendication 13 lorsqu'elle dépend de la revendication 5, dans lequel au moins un capteur (52) est configuré pour détecter la position de la valve de limitation de pression (50), et le contrôleur (36) est configuré pour ajuster au moins l'une desdites valeurs maximales selon la position détectée.

**15.** Système selon la revendication 14, dans lequel le contrôleur (36) est configuré pour diminuer la valeur maximale pour le courant dans le moteur (32) lorsque la valve de limitation de pression (50) passe d'une position ouverte à une position fermée.

**16.** Système selon l'une quelconque des revendications 13 à 15, dans lequel la valve de limitation de pression (50) est configurée pour passer de la position fermée a la position ouverte lorsque la pression du gaz comprimé par le mécanisme de pompage (30) est audessus de la pression atmosphérique.

**17.** Système selon la revendication 3, dans lequel au moins un capteur (60, 62, 70) est configuré pour fournir un signal indicatif d'une température dans le système de pompage, et dans lequel le contrôleur (36) est configuré pour ajuster au moins l'une desdites valeurs maximales en fonction des signaux reçus.

**18.** Système selon la revendication 17, dans lequel le contrôleur (36) est configuré pour ajuster la valeur maximale pour le courant dans le moteur (32) lorsque la température est au-dessus d'une première valeur prédéterminée.

**19.** Système selon la revendication 18, dans lequel le contrôleur (36) est configuré pour ajuster la valeur maximale pour la fréquence de rotation du moteur (32) lorsque la température est au-dessus d'une seconde valeur prédéterminée, la seconde valeur prédéterminée étant différente de la première valeur prédéterminée.

**20.** Système selon la revendication 17, dans lequel deux capteurs (60, 70 ; 62) sont configurés pour détecter des températures différentes respectives dans le système de pompage, et le contrôleur (36) est configuré pour ajuster au moins l'une des valeurs maximales en fonction d'une relation entre les températures detectées.

**21.** Système selon l'une quelconque des revendications 17 à 20, dans lequel au moins un capteur (62) est configuré pour fournir un signal indicatif de la température du gaz évacué du mécanisme de pompage (30).

**22.** Système selon l'une quelconque des revendications 17 à 21, dans lequel au moins un capteur (70) est configuré pour fournir un signal indicatif de la température du gaz admis au mécanisme de pompage (30).

**23.** Système selon l'une quelconque des revendications 17 à 22, dans lequel au moins un capteur (60) est configuré pour fournir un signal indicatif de la température du mécanisme de pompage (30).

**24.** Système selon l'une quelconque des revendications 1 et 2, dans lequel le contrôleur (36) est configuré aux valeurs maximales selon une relation de synchronisation prédéterminée.

**25.** Procédé de commande d'un système de pompage à vide comprenant un mécanisme de pompage à surpresseur sans huile (30) et un moteur (32) destiné à entraîner le mécanisme de pompage à surpresseur, procédé **caractérisé en ce qu'**il comprend les étapes consistant à régler une valeur maximale pour une fréquence de rotation du moteur et une valeur maximale pour un courant dans le moteur, et, pendant le fonctionnement du système de pompage, à ajuster lesdites valeurs maximales pour optimiser l'exécution du système de pompage, dans lequel la valeur maximale pour le courant dans le moteur (32) est augmentée au-dessus de la spécification nominale pour le moteur pendant le fonctionnement du système de pompage à une pression relativement élevée, et la valeur maximale pour la fréquence de rotation du moteur est augmentée pendant le fonctionnement du système de pompage à une pression relativement basse.

**26.** Procédé selon la revendication 25, dans lequel l'amplitude et la fréquence d'une puissance fournie au moteur (32) sont ajustées pendant le fonctionnement du système de pompage.

**27.** Procédé selon l'une quelconque des revendications 25 à 26, dans lequel au moins l'une desdites valeurs maximales est ajustée en fonction d'un ou plusieurs états de fonctionnement du système.

**28.** Procédé selon la revendication 27, dans lequel au moins l'une desdites valeurs maximales est ajustée en fonction d'au moins une pression de gaz dans le système de pompage.

**29.** Procédé selon la revendication 28, dans lequel la valeur maximale pour le courant dans le moteur (32) est diminuée lorsque la pression du gaz tombe en dessous d'une première valeur prédéterminée.

**30.** Procédé selon la revendication 29, dans lequel la première valeur prédéterminée est au-dessus de 100 mbar.

**31.** Procédé selon la revendication 29 ou la revendication 30, dans lequel la valeur maximale pour la fréquence de rotation du moteur (32) est augmentée lorsque la pression du gaz tombe en dessous d'une seconde valeur prédéterminée, la seconde valeur prédéterminée étant inférieure à la première valeur prédéterminée.

**32.** Procédé selon la revendication 31, dans lequel la seconde valeur prédéterminée est entre 1 mbar et 100 mbar.

**33.** Procédé selon la revendication 32, dans lequel la seconde valeur prédéterminée est entre 10 mbar et 100 mbar.

**34.** Procédé selon la revendication 27, dans lequel au moins l'une desdites valeurs maximales est ajustée en fonction d'une relation entre deux pressions de gaz dans le système de pompage.

**35.** Procédé selon l'une quelconque des revendications 28 à 34, dans lequel au moins une pression de gaz est la pression d'un gaz acheminé au mécanisme de pompage (30).

**36.** Procédé selon l'une quelconque des revendications 28 à 35, dans lequel au moins une pression de gaz est une pression d'un gaz évacué (22) du mécanisme de pompage (30).

**37.** Procédé selon l'une quelconque des revendications 25 à 36, dans lequel le système de pompage comprend une valve de limitation de pression (50) en aval du mécanisme de pompage (30), et au moins l'une des valeurs maximales est ajustée selon la position de la valve de limitation de pression.

**38.** Procédé selon la revendication 37, dans lequel la valeur maximale du courant dans le moteur (32) est diminuée lorsque la valve de limitation de pression (50) passe d'une position ouverte à une position fermée.

**39.** Procédé selon la revendication 27, dans lequel au moins l'une desdites valeurs maximales est ajustée en fonction d'au moins une température du système de pompage.

**40.** Procédé selon la revendication 39, dans lequel la valeur maximale pour le courant dans le moteur (32) est diminuée lorsqu'au moins une température est au-dessus d'une première valeur prédéterminée.

**41.** Procédé selon la revendication 40, dans lequel la valeur maximale pour la fréquence de rotation du moteur (32) est augmentée lorsqu'au moins une température est au-dessus d'une seconde valeur prédéterminée, la seconde valeur prédéterminée étant différente de la première valeur prédéterminée.

**42.** Procédé selon la revendication 39, dans lequel au moins l'une desdites valeurs maximales est ajustée en fonction d'une relation entre au moins deux températures du système de pompage.

**43.** Procédé selon l'une quelconque des revendications 39 à 42, dans lequel au moins une température est la température du gaz évacué (22) du mécanisme de pompage (30).

**44.** Procédé selon l'une quelconque des revendications 39 à 43, dans lequel au moins une température est la température du mécanisme de pompage (30).

**45.** Procédé selon l'une quelconque des revendications 25 à 26, dans lequel les valeurs maximales sont ajustées selon une relation de synchronisation prédéterminée.

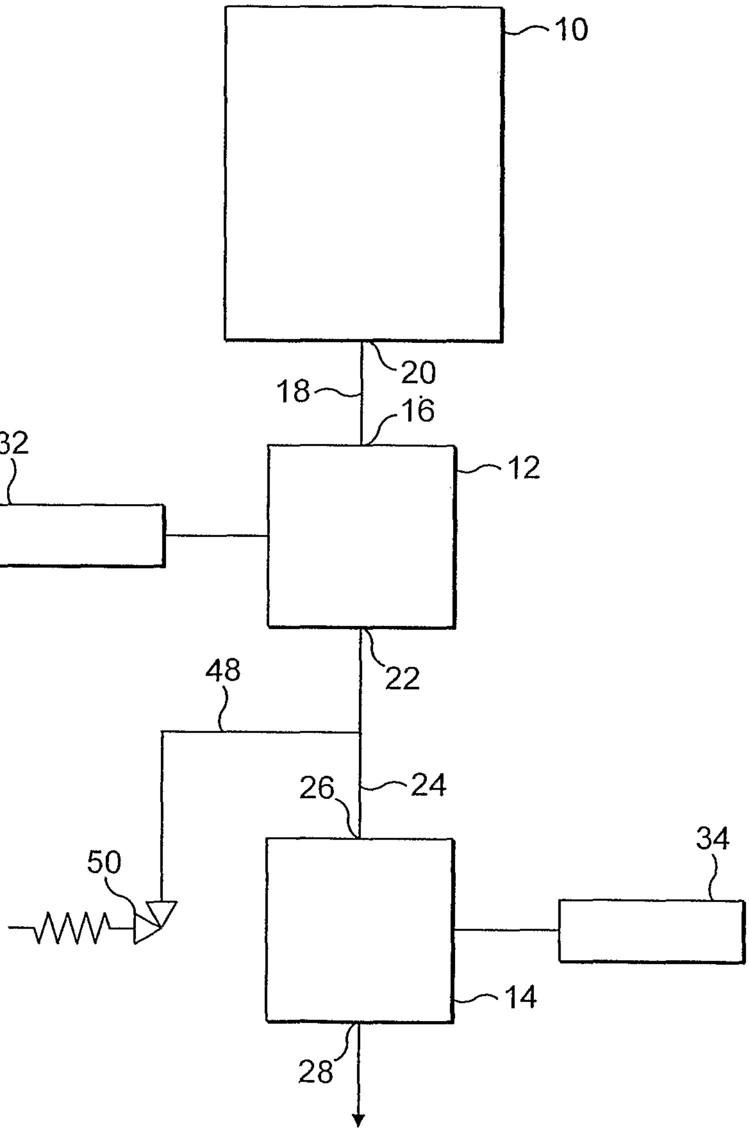


FIG. 1

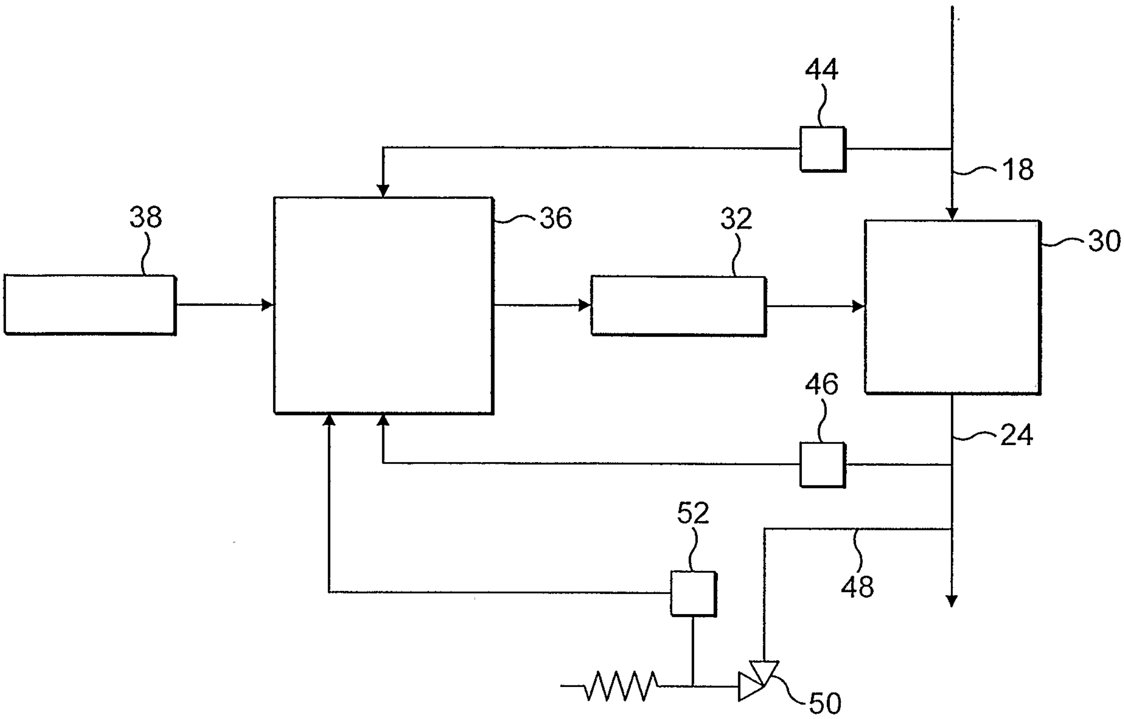


FIG. 2

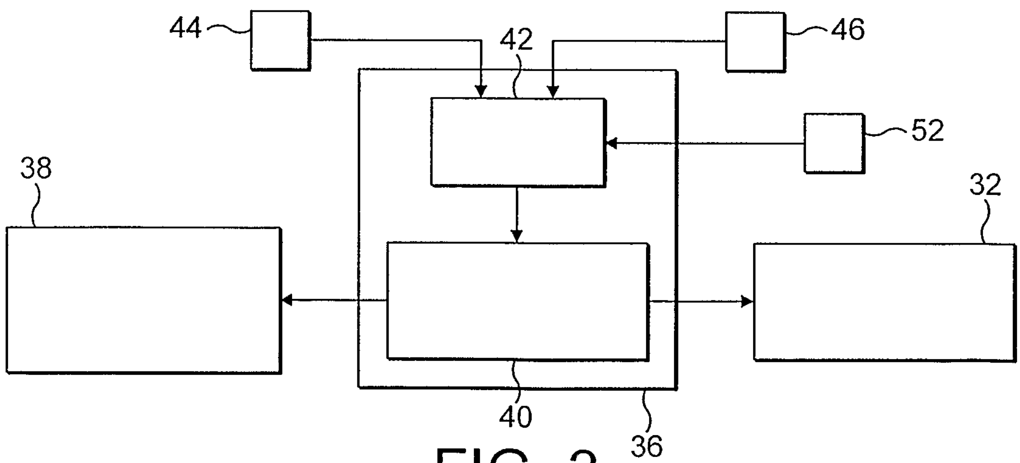


FIG. 3

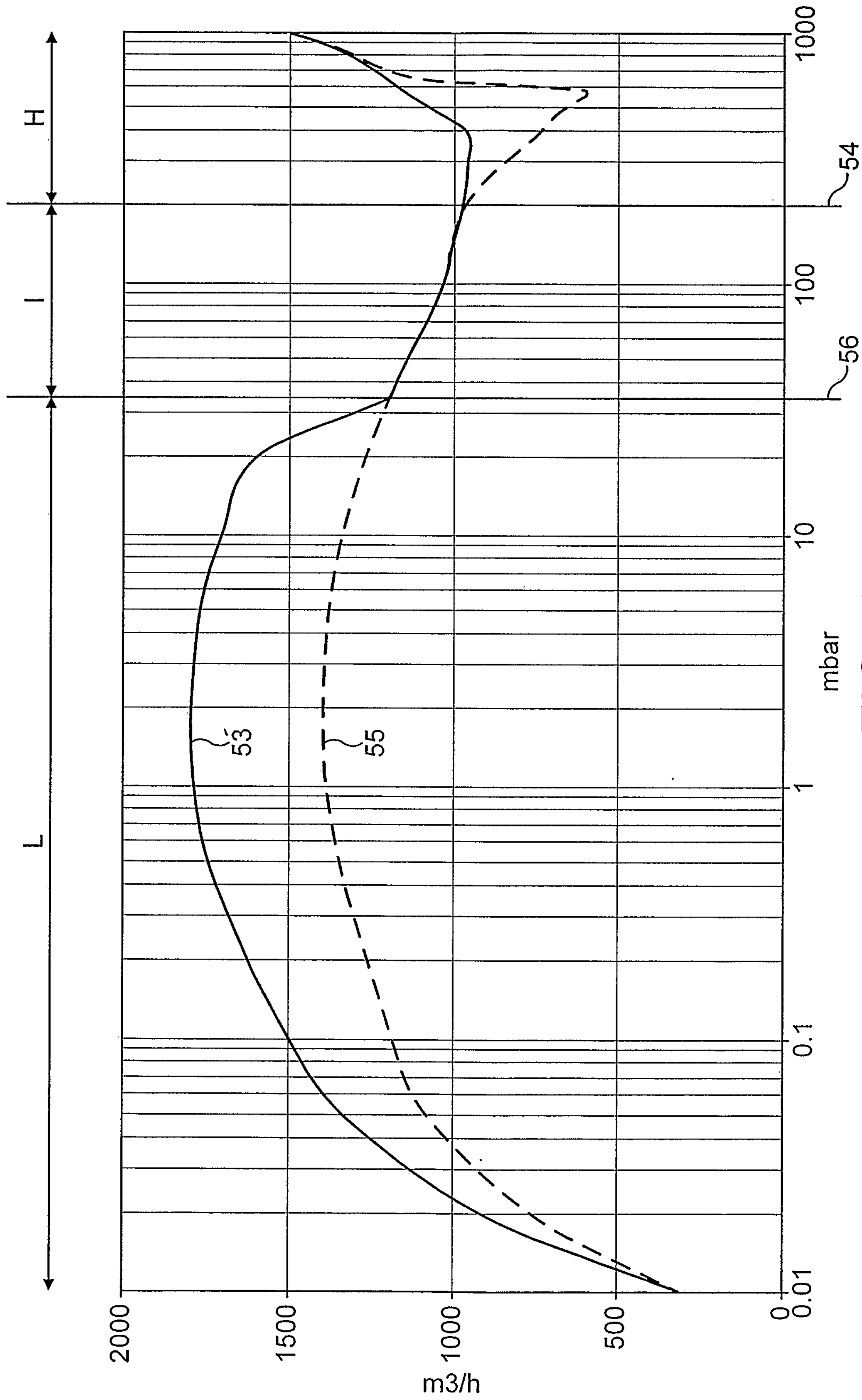


FIG. 4

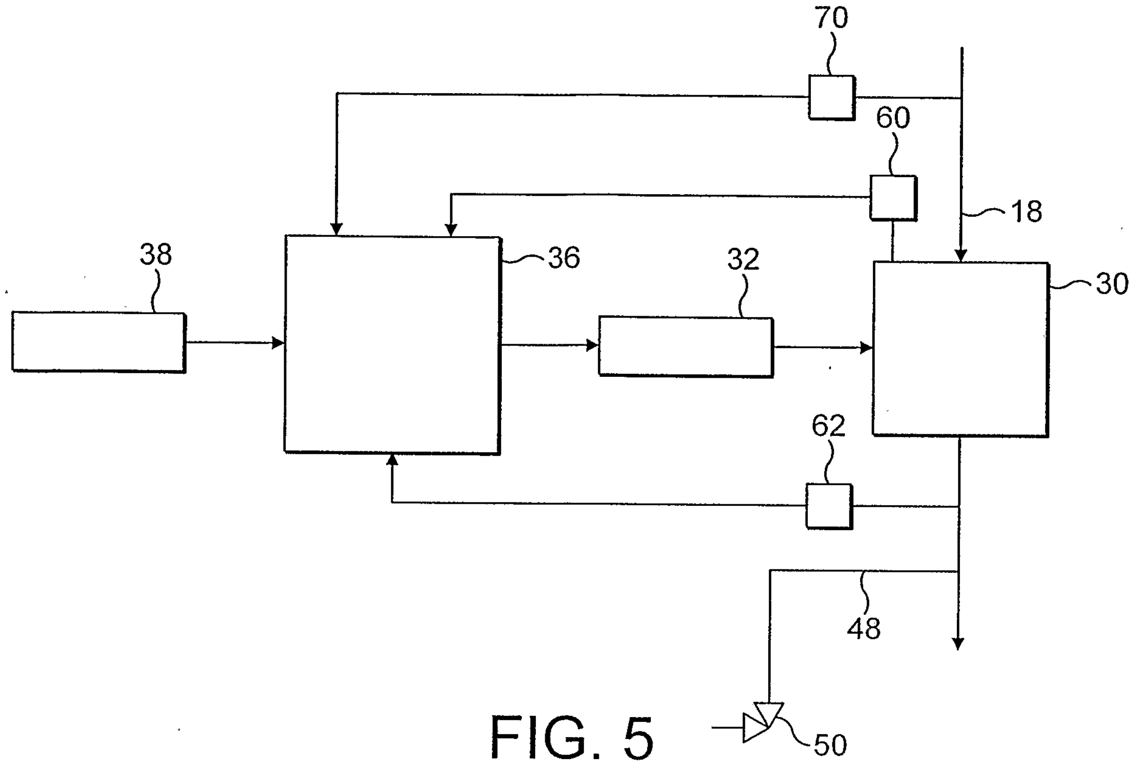


FIG. 5

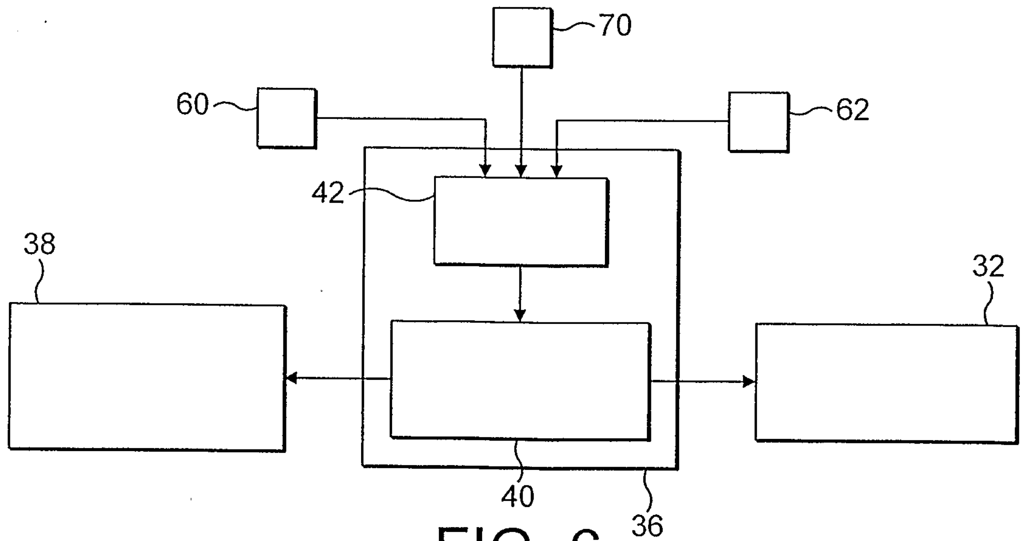


FIG. 6

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description

- US 5944049 A **[0003]**
- EP 1482178 A **[0003]**